A Geological and Geophysical Information System for the Middle East and North Africa

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Abstract

We are collecting and organizing all available seismological, geophysical, topographical, geological, and satellite imagery datasets for the Middle East and North Africa into a digital information system that is quickly accessible via the Internet from Cornell and can be utilized in modeling and display programs. We are focusing our efforts on the Middle East and North Africa and locating and digitizing published crustal thickness, depth to basement, and crustal velocity and density structures, primarily as interpreted from seismic refraction and reflection, gravity and drill hole datasets. We have digitized some gravity maps and key geologic features for the Middle East. All data are being stored in ArcInfo Geographic Information System (GIS), the most widely used full-featured GIS. We are also maintaining a comprehensive bibliography of all the relevant references in a computer database. We are also developing new tools to extract and visualize the digitized databases. These new analysis tools will allow one easily to find and display any data and information in our database.

The databases being developed are essential for a successful global monitoring system, such as the International Data Center (IDC) and the GSETT-3 experiment. The final products, for example, will significantly contribute to accurate locations of seismic events, understanding high-frequency wave propagation at regional distances, and better characterization and calibration of seismic events in the region. The database, except the DMA topography, is accessible via the Internet from Cornell and can be accessed by ARPA/DOE/AFTAC/AFOSR researchers. Our Web address is: **"http://www.geo.cornell.edu/geology/me_na/main.html".**

Key words: Geographic Information System (GIS), digital databases, Middle East, North Africa

Objective

It is essential for the implementation and subsequent CTBT monitoring efforts that multidisciplinary information on any given region is readily available and accessible in a digital on-line format via electronic networks for use by concerned researchers and decision makers. New data, both seismological/geophysical and geological, are required to constrain advanced theoretical and modeling efforts in order to better understand the propagation of high-frequency seismic waves produced by very low yield events at regional distances. For these monitoring efforts to be successful, researchers must be able to detect, characterize, calibrate, discriminate, and verify any suspect event for most regions on earth. As important to the success of any monitoring strategy, such data must be swiftly accessible to researchers via networks in order to integrate with real-time recorded events to provide ground-truth for fast verification purposes. Our objectives are to collect and organize all available seismological, geophysical, topographical, and geological datasets for the Middle East and North Africa and to form a digital information system that is accessible via the Internet (except the DMA topography) from Cornell.

In implementing these objectives, we are careful to focus on monitoring problems that are addressed or soon will be attacked by the different research groups. It is important that our digital, network-accessible information system is complete, comprehensive, multidisciplinary, unified, easy to update, and of direct relevance to monitor the negotiated CTBT or any other agreements. Because of the unique and considerable contacts between Cornell University and scientists and institutions in most of the countries of the Middle East and North Africa we are able to initiate contacts and assemble large data sets that need to be computerized to serve the ongoing and future work on monitoring the CTBT.

Research Accomplished

We have been focusing our efforts to develop and provide diversified databases on the Middle East and North Africa, including published results based on gravity, seismic refraction, and geologic/tectonic observations (e.g., Best et al., 1990; Seber et al., 1993; Barazangi et al., 1993). From available seismic refraction and gravity interpretation publications, we have digitized many of the crustal scale profiles available in the literature (Figure 1). This work has almost been completed. In addition to digitizing these profiles, we have written new tools that will make selection, identification and analyzing of these data quite easy. This eliminates potential problems that could have been faced when a user wanted to use the system without much ArcInfo knowledge. The new tool is all menu driven and requires no special training on ArcInfo to use it. We have put all the seismic refraction and gravity interpretations in one "coverage". The profile locations were digitized as accurately as possible. Then, the interpreted sections were digitized and "attached" to profiles locations. For refraction and gravity

profiles velocity and density information above and below each interface are recorded and saved in the coverage as attributes to the profile.

We have also complied a seismicity database from the USGS NEIC database. We extracted all the data (including explosions, mine blasts, rock bursts, etc.) for the Middle East and North Africa regions. This database is now a part of the databases at Cornell (Figure 2). We are developing menu driven tools that will make selection, search, and printing quite easy for an analyst or a researcher. We have also added to this database the Harvard CMT focal mechanism solutions of large earthquakes that occurred between 1977 and 1992 (Figure 2).

We have finished compiling a crustal scale Bouguer gravity data for Syria, Israel and Lebanon (Figure 3). This Bouguer gravity database is a part of our attempt to form a uniform grided Bouguer gravity data set for the entire Middle East, which then can be used along with previously interpreted seismic refraction profiles to obtain a Moho map for the whole Middle East. We are also compiling all available depth to Moho maps for the area. We digitized a map of Moho depth for Egypt (Figure 4), and Israel. These data sets will also be used in our efforts to map the Moho depth for the Middle East.

We have also developed a "profile maker" which runs under our World Wide Web (WWW) server (Figure 5). These tools, which are now under final testing, will allow any user to access our database through a client software (like Mosaic or Netscape) and make a crustal cross section for any region in Eurasia, including the Middle East and parts of North Africa. A user can define a profile from a computer screen and ask for the crustal cross section (which will include topography, basement, and Moho). The user can choose to use different data bases when available, and copy the graphics and/or ASCII files from our ftp server.

We still continue to build and expand our bibliographic database. References to books, journal articles, reports and other published literature are stored with the usual information on title, date, author, journal, page numbers, etc. and with searchable keywords on the content. This is becoming a comprehensive database of seismology, crustal structure, geology, and geophysics literature for the Middle East and North Africa. We will continue to update and add to this bibliographic database.

Conclusions and Recommendations

The data of our digital geological and geophysical information system will be useful for the interpretations of the seismic data in CTBT and nonproliferation monitoring. Geophysical and geological datasets can provide important ancillary information on the structure of the crust and upper mantle that may affect the

propagation of seismic phases through the continental lithosphere. In turn, this bears on the detection, discrimination, and yield estimation of nuclear explosions. The rapidly changing geopolitical situations in Eurasia, North Africa, and the Middle East make it imperative that databases are extended to areas outside the former Soviet test sites.

To monitor the anticipated multilateral comprehensive nuclear test ban and nonproliferation treaties, we recommend that multidisciplinary information on any given region be readily available and accessible in digital form via the Internet for use by concerned researchers and decision makers. New data, both seismological/ geophysical and geological, are required to constrain advanced theoretical and modeling efforts in order to better understand the propagation of seismic waves produced by very low magnitude events at regional distances. For these monitoring efforts to be successful, researchers must be able to detect, characterize, calibrate, discriminate, and verify any suspect event for most regions on earth. As important to the success of any monitoring strategy, such data must be swiftly accessible in digital form to researchers via networks in order to integrate with real-time recorded events to provide ground-truth for fast verification purposes.

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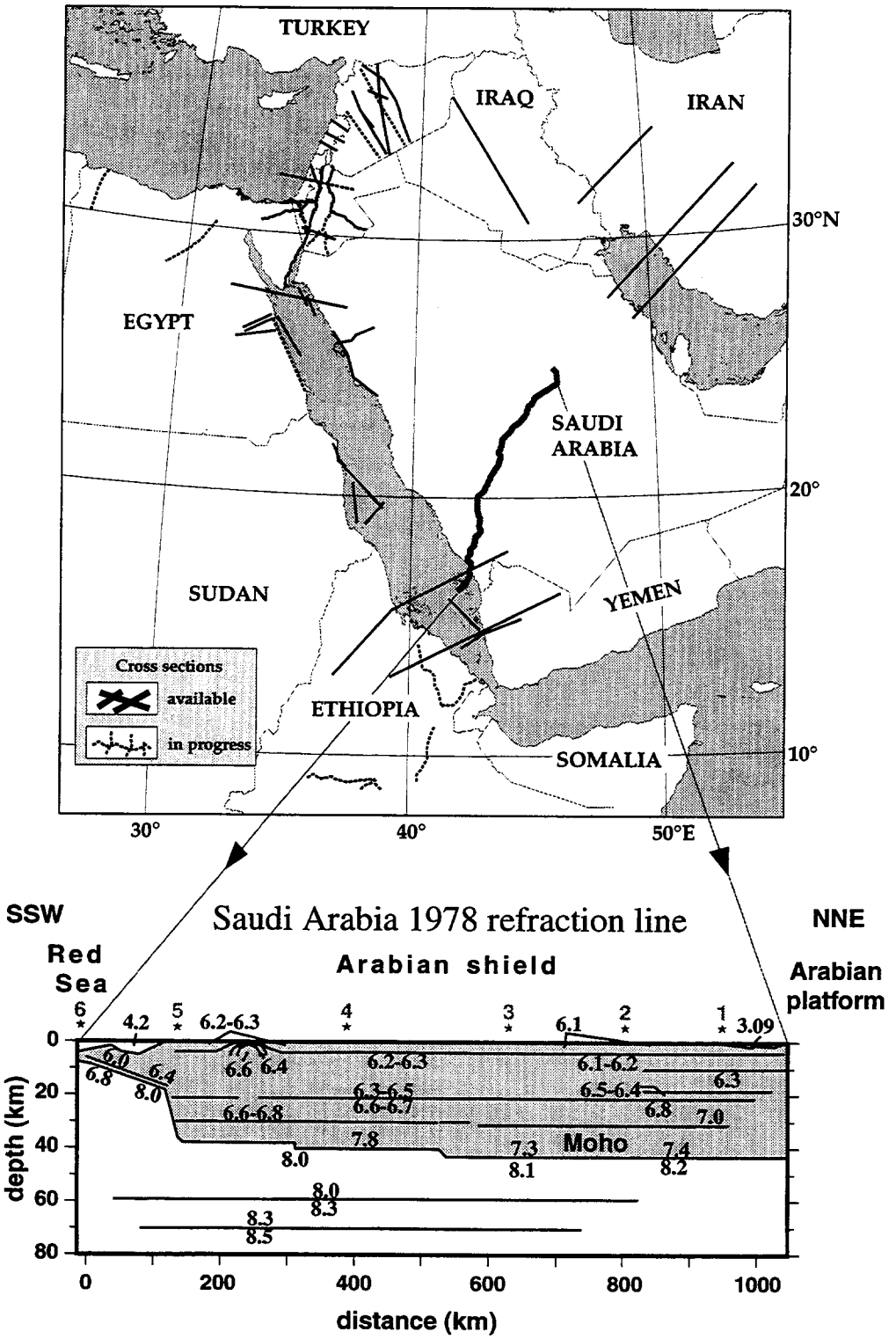
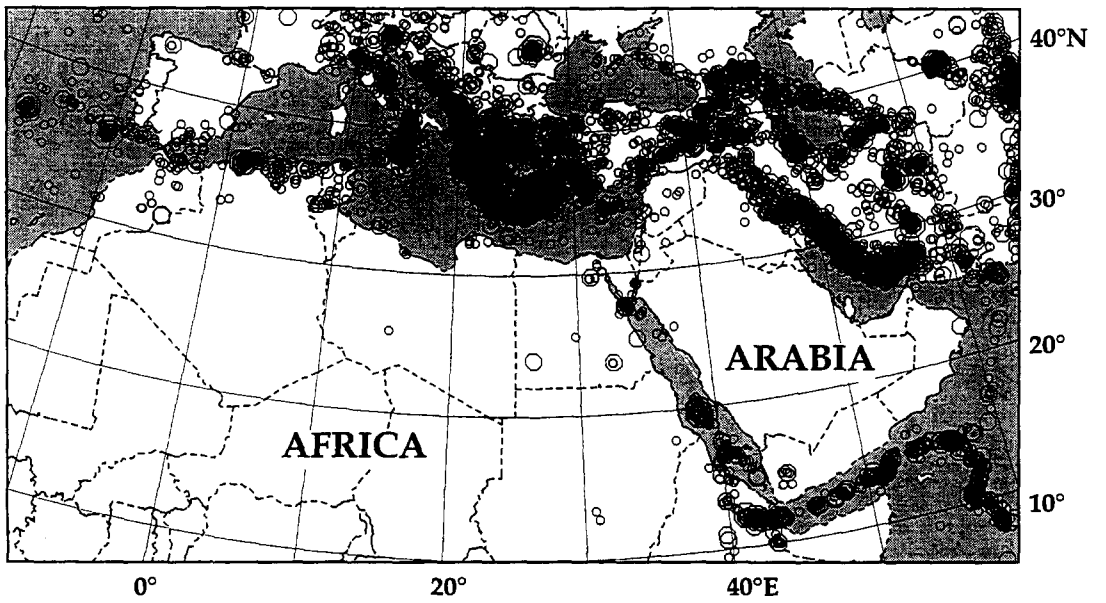


Figure 1. Map of the Middle East showing locations of crustal profiles. Both refraction and gravity profiles are shown as thick lines. The Saudi refraction profile (after Healy et al., 1982) is also shown as an example (shot points, stars, and velocity in km/s are shown).

Seismicity of the Middle East and North Africa
(1960-1990)



Focal Mechanism Solutions of the Middle East
and North Africa (1977-1992)

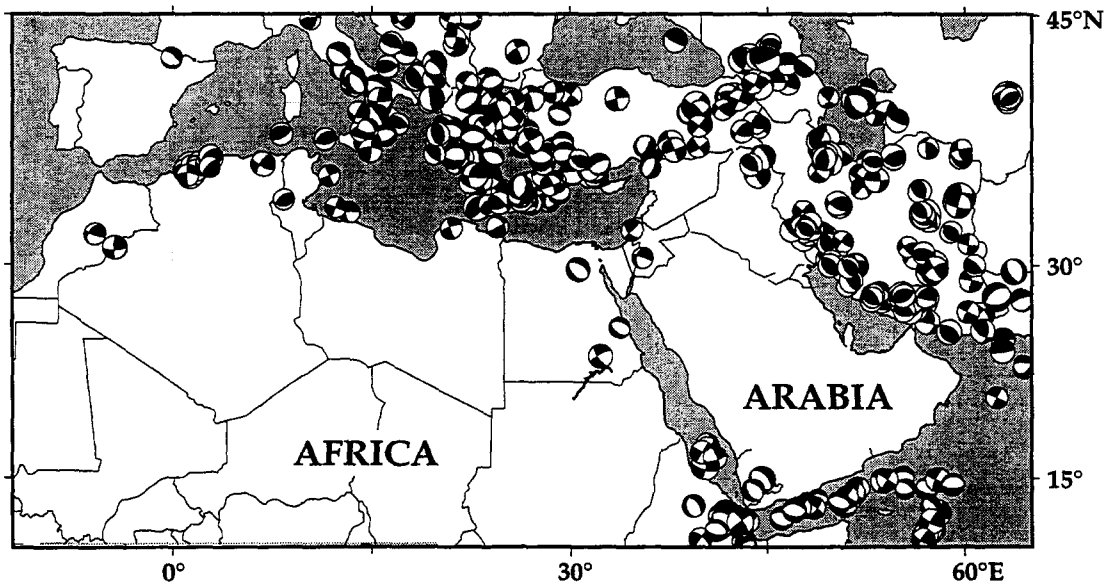


Figure 2. Seismicity and available focal mechanisms for the Middle East and North Africa.

Bouguer Gravity Map of Syria, Lebanon and Israel

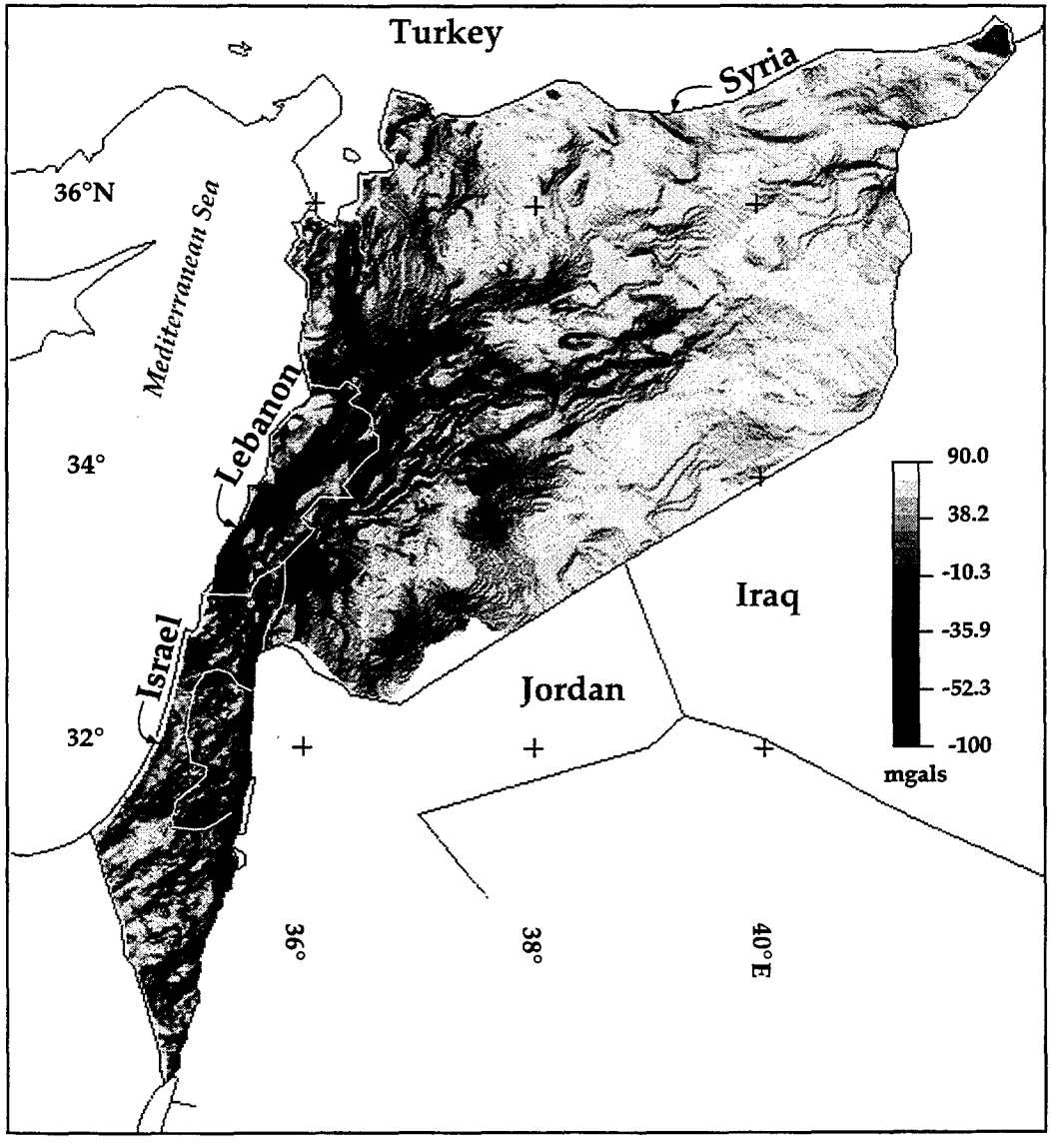


Figure 3. Shaded imsge of Bouguer gravity map of Syria, Lebanon, and Israel

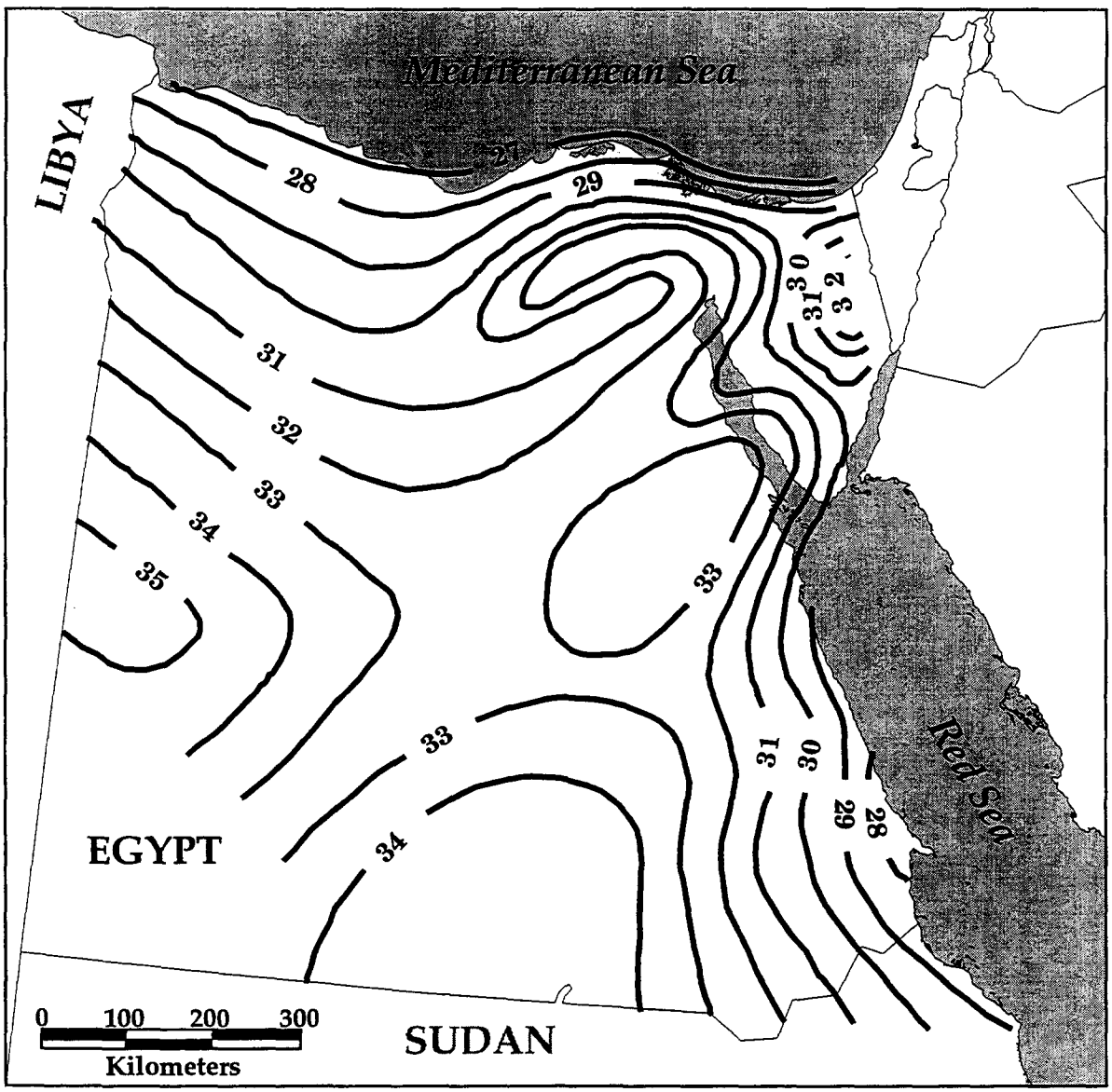


Figure 4. Contour map of depth to Moho in Egypt (after Makris et al., 1987).

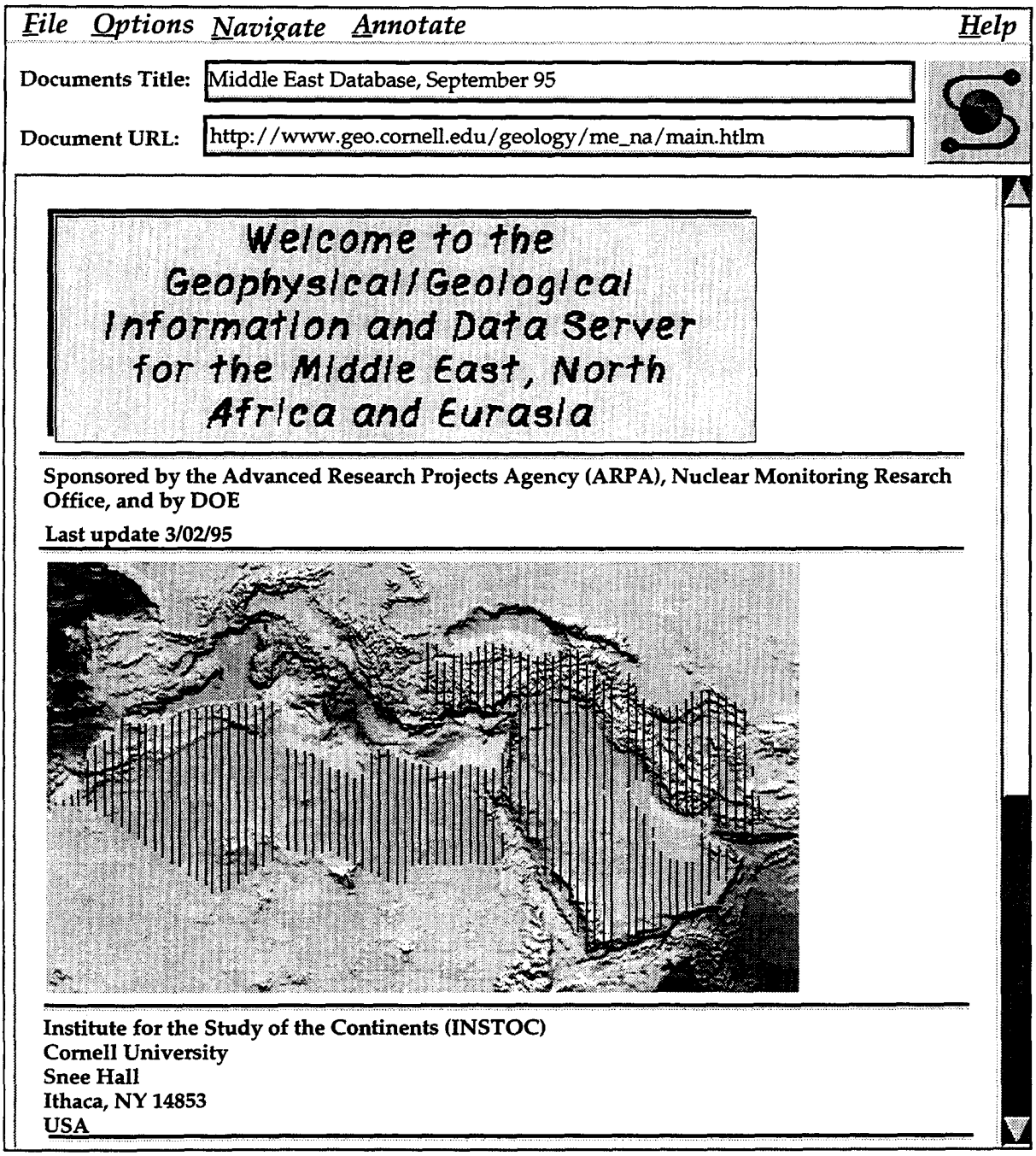


Figure 5. First page of our WWW server. Most of our data can be found in this server.